RESEARCH BULLETIN 766 NOVEMBER 1955

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OHIO AGRICULTURAL EXPERIMENT
STATION - - WOOSTER, OHIO

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ACKNOWLEDGMENT

These experiments were supported in part by a grant-in-aid from the Nitrogen Division of Allied Chemical and Dye Corporation, 40 Rector St., New York, N. Y., through Dr. D. F. Green. The assistance of Dr. C. F. Rogers in carrying out these studies is gratefully acknowledged.

THE USE OF UREA TO INCREASE THE CRUDE PROTEIN CONTENT OF CORN SILAGE FOR FATTENING STEERS

ORVILLE G. BENTLEY, EARLE W. KLOSTERMAN
and PAUL ENGLE

Corn silage has been recognized as an excellent cattle and sheep feed for many years. Besides the stalks and leaves, the 30 to 35 percent dry matter content of typical corn silage contains about 40 percent corn grain. Thus it is not surprising that silage has come to be recognized as a basic high-energy feed for cattle and sheep in many parts of the United States.

Protein supplementation of corn silage enhances its feeding value since corn silage, on a dry matter basis, contains only 8 to 10 percent protein. Extensive studies on the value of feeding protein with corn silage for fattening calves and steers have been carried out by the Ohio Station at the Madison County Experiment Farm. It was found that yearling steers fed 1.5 pounds of soybean oil meal, a full feed of corn silage, and some hay gained well and made efficient and economical use of their feed. Acre beef yields from corn silage were particularly favorable as compared to that obtained by feeding the corn as grain or to feeding hay-crop silage.

In an attempt to increase the crude protein content of corn silage, a series of studies were initiated in 1952 in which urea was added to the chopped corn at the time of ensiling. Urea is a simple, synthetic, non-protein nitrogen compound which can be used as a source of nitrogen by cattle and sheep. In the rumen the urea is converted to ammonia and carbon dioxide and the ammonia nitrogen can then be used by the rumen microflora for their growth. Ultimately the rumen micro-organisms and protozoa are killed as they pass through the small intestine and are digested like a common feedstuff; thus, the non-protein nitrogen which has been incorporated into amino acids by the microflora is converted to compounds utilizable by the animal itself.

Further, it is known that utilization of non-protein nitrogen, e.g. urea, is promoted in the rumen by the feeding of high energy feeds, such as grains, molasses, etc. It seemed then that corn silage—a high-energy, low-protein feed—might be an ideal type of feed to consider for use with urea as a means of increasing its crude protein content.

The distribution of water-soluble urea in the liquid phase of silage was considered a decided advantage since this would tend to distribute the urea evenly. Another advantage from the feeding standpoint was that the urea would be in the major portion of the ration, thus avoiding problems of palatability or a danger of over-feeding on urea.

There has been some work done at other Stations on the addition of urea to various types of silages. These reports will only be discussed briefly here.

Cullison at Mississippi added 10 pounds of urea per ton to sweet sorghum which appeared to increase its feeding value for beef cows. Woodward and Shepherd added a similar amount of urea to corn silage fed to dairy cows and obtained favorable results. Davis and coworkers in Florida treated sorghum silage with 10, 30 or 50 pounds of urea per ton of silage made in experimental silos. Acceptance tests indicated that the silage with 10 pounds of urea was satisfactory while the 50 pounds per ton silage was rejected. The 30 pound urea per ton was intermediate in acceptability.

Workers at the South Carolina Agricultural Experiment Station reported that urea additions to corn silage caused a 70% loss in carotene. Ten pounds of urea per ton were added in a 25% water solution. A similar amount of water was added to the non-urea treated silage. Contrariwise, in the Mississippi tests with sweet sorghum silage, carotene was 50% higher in the urea-treated silage.

Experiments on the use of urea in making corn silage are in progress at the North Carolina Experiment Station. Preliminary results indicate that under their conditions urea did not improve the feeding value of the silage as determined by animal performance. (Personal communication from Professor Lemuel Goode).

Urea additions to grass silage at the Massachusetts Station made the silage unpalatable. Some work on the use of urea in both grass and sorghum silage is being done at Ardmore, Oklahoma, in cooperation with the Oklahoma Station.

Although some work has been done with urea-treated corn silage, the information available on this method of urea feeding is limited, especially in its use in the Corn Belt area in fattening-type rations for cattle.

The results of three feeding experiments with steer calves, metabolism studies with lambs, using corn-urea silage, and some chemical analyses of the treated and non-urea treated corn silages are reported herein.

MAKING THE SILAGE

Corn in the early dent stage was cut using an all-crop harvester. The chopped corn was handled in wagons equipped with mechanical unloading devices and 25 ton (approximately) upright, cement stave silos were filled with the conventional silo blower.

When urea was to be added, the calculated amount of a feed grade urea was sprinkled over the top of the loads of corn which had been weighed. Urea was added to the green chopped corn at the rate of 17 pounds per ton in 1952-1953, 25 pounds per ton in 1953-1954, and 20 pounds per ton in 1954-1955. The amount of urea to be added was determined by estimating the amount of urea nitrogen that should be contained in a daily feed of silage for a fattening steer. Besides the urea feed supplement, a urea-dicalcium phosphate mixture was added to the silage in one silo in 1954-1955. This addition of 22 pounds per ton of chopped corn supplied 20 pounds of urea and 2.0 pounds of dicalcium phosphate.

With regard to mixing the urea into the silage, the mixing which occurred during the unloading of the chopped corn from the wagons into the blower and in the process of blowing the corn into the silo was found to be sufficient. This was indicated by the results of chemical analyses made on samples of silage taken at various levels in the silo.

Corn silage made in the usual manner from the same field of corn and stored in similar silos was used as a source of comparable untreated silage.

RESULTS

Chemical Analyses:

The analyses summarized in Table 1 indicate that the crude protein content of the dry matter in the corn silage was increased by the urea additions. This increase varied with the amount of urea added at the time of ensiling the increase being 62% in 1952-1953, 124% in 1953-1954, and 76% in 1954-1955. These increases in crude protein could be accounted for largely on the basis of the increased amounts of ammonia and urea present in the urea-treated silage. In 1952-1953, 80.6%; in 1953-1954, 90.3% and in 1954-1955, 85.0% of the increased crude protein was in the form of additional ammonia and urea. The remainder of the increased nitrogen in the urea silages was apparently due to non-protein nitrogen compounds not determined by our procedure. This may represent an actual increase in the true protein content of the silage.

TABLE 1.—Chemical Analyses of Corn Silage and Corn-Urea Silages* †

	Dry matter	Crude protein (wet sample)	Crude protein (dried sample)	Ammonia nitrogen	Urea nitrogen	pH
	%	%	%	%	%	
1952-1953:						
Corn silage	33.1	9.3	9 7	0.13	0.012	——
Corn silage + 17 lb. urea per ton	34.2	15.1	12.6	0.68	0.21	——
1953-1954:						
Corn silage	36.8	8.9	8.9	0.08	0.0	4.70
Corn silage + 25 lb. urea per ton	34.8	19.9	12.7	1.6	0.07	7.60
1954-1955:						
Corn silage	35.2	8.3	9.1	0.08	0.002	3.70
Corn silage + 20 lb. urea per ton	34.8	14.6	15.6	0.39	0.55	4.05
Corn silage + 20 lb. urea + 2.0 lb. dicalcium phosphate per ton	37.1	13.4	14.8	0.38	0.70	3.95

*All analyses expressed on a dry matter basis. The average results for 1952-1953 represent 3 samples; 1953-1954, 7 to 11 samples; and in 1954-1955, 2 samples of silage.

†Percent recovery of the added urea nitrogen from the corn silage was calculated as follows

$$\frac{(\text{Urea silage}) \quad (\text{Control silage})}{(2000 \times \%\ \text{D.M.} \times \%\ \text{Protein}) - (2000 \times \%\ \text{D.M.} \times \%\ \text{Protein}) \times 100}$$

Protein equivalent added per ton as urea (2.62 × pound of urea)

The apparent recovery of the urea, based on the average analyses presented in Table 1, can be calculated. The increase in crude protein due to urea treatment, expressed as the percentage of the amount of crude protein added as urea, gives the following apparent urea recovery: (1) 1952-1953, 94%; (2) 1953-1954, 112%; (3) 1954-1955, 82%. Such calculations are subject to a certain amount of error. However, they would indicate that the urea loss was not excessive from any of the silages. Again, the rather high dry matter content of the 1953-1954 silage may be a source of possible error.

Urease, an enzyme which hydrolyzes urea to ammonia and carbon dioxide from either plant or bacterial sources, apparently was responsible for breaking down a large portion of the urea. Ammonia will react with the silage acids (acetic, lactic, etc.) to form ammonium salts. In 1953-1954, there appeared to be more ammonia from the urea than could be combined with the acids. This is indicated by the high pH of

the silage, 7.60. Incidentally, this silage was high in dry matter content because of dry weather conditions in the fall of 1953. The pH of this untreated silage was somewhat higher than is normally expected for good silage—4.7. Also, it was observed that this corn-urea silage had a distinct odor of ammonia, especially if it was exposed to the air several hours before feeding.

However, in 1954-1955 the pH of the urea-treated silage was similar to that of the normal control silage. Contrary to the 1953-1954 silage, the odor of ammonia was rarely detected. Apparently in this silage there was a sufficient amount of the fatty acids in the silage to bind the ammonia which was released from the urea as ammonium salts and which are not volatile at the usual air temperatures. In addition, this silage contained 0.55% nitrogen still in the form of urea, which is odorless.

The addition of the urea did not appear to affect the total carotene content of the silage. Samples exhaustively extracted with a 1:1 mixture of acetone and petroleum ether with the total extracted pigments expressed as carotene gave values of 65 for corn silage, 75 for the corn-urea silage, and 46 for the corn-urea-dicalcium phosphate silage (ugm. per gm. dry matter) in the 1954-1955 experiment. All these values are considered above an average range as found by analyses of other corn silage at this Station.

Since the method of sample preparation could affect the results of the analyses carried out on the silage, a brief description of the methods are included.

Total nitrogen, ammonia, and urea nitrogen determinations were made on triplicate 10 gm. samples of wet silage. It was found that, with urea-treated silage samples especially, considerable ammonia was lost during drying of the sample.

Ammonia nitrogen was determined using the fresh material by the A.O.A.C. procedure with a macro Kjeldahl apparatus. Urea nitrogen was converted to ammonia by suspending 10 gm. samples of fresh corn silage in a water-buffer mixture (pH 7.0) and then adding 200 mg. of finely ground purified jackbean urease. This was allowed to stand at room temperature for about one hour and the ammonia nitrogen distilled as before. The increase in ammonia nitrogen due to treatment with the urease enzyme preparation was considered to come from urea present in the silage sample.

Since the possibility of sampling error on such a material as corn silage is large, samples of 50 to 100 gm. of silage were exhaustively extracted with hot water. The soluble nitrogen, e.g. ammonia, urea,

etc., should be removed by this procedure. It was found that ammonia and urea values thus obtained compared favorably with values found on direct analyses of the 10 gm. samples of wet silage in the Kjeldahl flasks.

Metabolism Experiments With Wethers:

To determine the digestibility of the crude protein in the corn silage and the corn-urea silage, a series of digestion studies were conducted with wethers. These studies were carried out in the usual manner using a 7-day period for adjustment to the various silages followed by a 7-day collection in special metabolism crates, as shown in Figure 1. The same lambs were used for all digestion experiments; thus all the lambs were fed each silage for a 14-day period. The studies on digestibility were conducted with the silage made in the 1953-1954 season. The results of these experiments are summarized in Table 2.

The apparent digestibility of the dry matter was about the same for all rations. Supplementation of corn silage with either a soybean oil meal-corn mixture, a urea-corn mixture, or soybean oil meal gave the expected increased apparent digestion of the protein. Likewise,

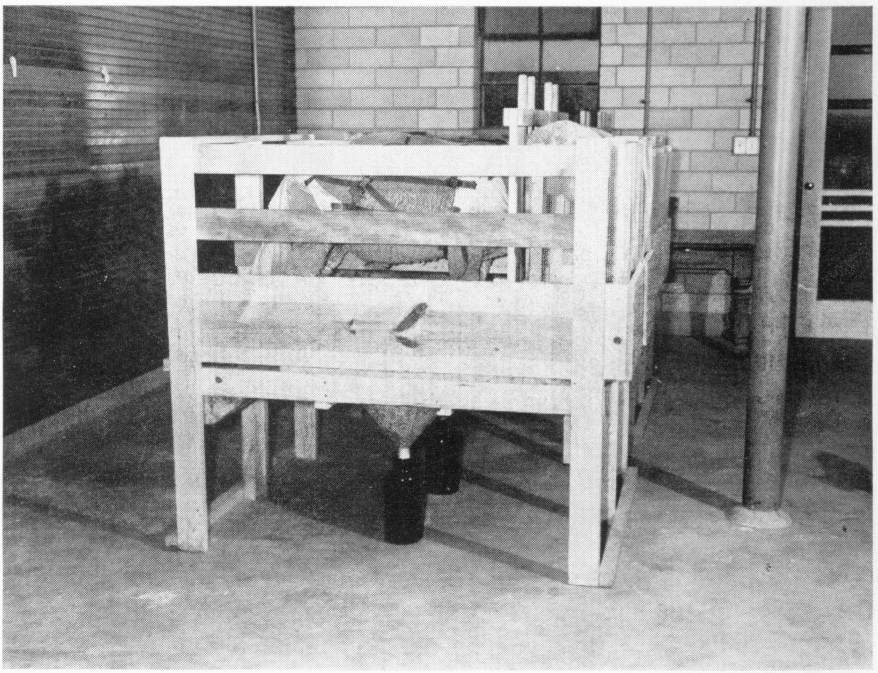

Fig. 1.—Metabolism crates used in digestibility studies of urea-treated corn silage and other rations.

improved protein digestion was obtained with corn silage to which urea had been added, demonstrating that the added urea was well utilized. Nitrogen retention data calculated from nitrogen balance studies indicate that the lambs were essentially at nitrogen equilibrium.

TABLE 2.—Digestibility Studies With Wethers Fed Corn Silage With and Without Protein Supplements or Corn-Urea Silage*

	Experiment Number						
	1	2	3	4	5†	6†	7†
	Corn silage	Corn-urea silage	Corn silage + soybean oil meal	Corn silage + ground corn-urea	Corn silage + corn-urea silage	Corn silage + ground corn-urea	Corn silage + ground yellow corn + soybean oil meal
Number of animals	4	3	4	3	3	4	3
Dry matter intake, gm per lamb—7 day period							
Corn silage	3,557 0	———	———	3,597 0	2 650 0	3,652 0	3,683 0
Corn urea silage	———	3,363 0	3,387 0	———	663 0	———	———
Soybean oil meal	———	———	911 0	———	———	———	200 0
Ground yellow corn	745 0	754 0	———	774 0	770 0	719 0	560 0
Urea	———	———	———	125 0	———	33 0	———
Refuse, total dry matter, gm	119 0	187 0	———	20 0	———	———	———
Total dry matter intake, gm	4,183 0	3,930 0	4,298 0	4,476 0	4,223 0	4,543 0	4,583 0
Total nitrogen intake, gm	59 9	116 7	118 4	121 9	69 0	79 8	80 4
Crude protein, percent total dry matter intake	9 0	18 6	17 2	17 0	10 2	11 0	11 0
Total cellulose intake, gm	794 1	816 1	876 4	808 9	610 0	838 3	827 0
Cellulose, percent total dry matter intake	19 0	20 8	20 4	18 1	14 4	18 5	18 0
Apparent digestibility, percent dry matter	74 4	73 4	75 0	74 8	75 3	75 1	77 7
Crude protein	60 5	77 7	80 3	79 9	67 4	71 2	72 9
Cellulose	63 3	68 5	71 6	66 7	57 2	67 9	71 1

*The same wethers were used for each digestion trial and averaged 119 pounds in weight

†Dry matter intake includes 140 gms of a mineral mixture

Because of the high protein content of the 1953-1954 corn-urea silage, wethers fed the silage alone were receiving a 17 to 19 percent crude protein ration. A 10 to 12 percent crude protein ration is usually considered as being adequate for wethers of this weight (100-130 lb.); therefore, the corn-urea silage was mixed with the straight corn silage to reduce the crude protein level of the ration. Two series of experiments are reported in Table 2—one with a high-protein intake and the other with the 10 to 12 percent protein intake.

CATTLE FEEDING EXPERIMENTS

Three cattle feeding experiments were conducted to study the palatability and feeding value of urea-treated corn silage. Hereford steer calves of good quality were used in each experiment. They were fed in lots of seven each in a large barn with free access to water, salt and a mineral mixture of two parts steamed bone meal, two parts ground limestone and one part salt, by weight. In all instances the lots of cattle were fed all of the silage they would consume without wastage.

The first two experiments were conducted with only a limited number of steers, the main objectives being to study the palatability and chemical composition of the urea-treated silages. Because of the limited amount of silage used from each silo in these experiments, special methods were employed to prevent spoilage. Silage caps were kept over the silage in the silos at all times. Approximately once a week these caps were removed and the volume of silage transferred to large boxes in the barn. This silage was then treated with sulphur dioxide gas and covered with boards. The amount of silage used for each morning and evening feeding was removed from these boxes and the silage remaining was leveled and recovered with the boards until the next feeding. Although not preserving silage exactly the same as that fed in the usual manner, in general this procedure proved satisfactory. When handled in this way, especially during warm weather, there was a distinct odor of ammonia from the urea-treated silage. This odor, however, did not appear to affect the palatability of the silage as, during both years that this procedure was used, the cattle fed the urea-treated silage ate fully as much per head daily as those fed the untreated silage.

In the third experiment, larger numbers of cattle were fed so that no special methods for preserving the silage during the feeding period were required. The silage from the various silos was removed and fed daily. Under these conditions, and with the acidity discussed previously, all silages were of excellent quality and only occasionally could traces of ammonia odor be detected in the urea-treated silages.

The results of the first experiment, conducted during the feeding season of 1952-1953, are presented in Table 3. It will be noted that the cattle fed corn silage and soybean oil meal gained somewhat faster than those fed the urea-treated silage. They, however, were also fed slightly more energy in that, for the first 84 days of the 196-day experiment, they received 1.5 pounds of soybean oil meal per head daily while those fed the urea-treated silage received no concentrate in addition to the silage. For the last 112 days of the experiment, ground ear corn was fed to both lots but a larger amount was fed with the urea-treated silage to equalize energy intake during this part of the experiment. The average daily corn consumption listed in Table 3 was the average for the total 196 day feeding period.

TABLE 3.—Value of Urea-treated Corn Silage For Fattening Cattle

Experiment I — 1952–1953

	Lot 7 Corn silage	Lot 8 Urea-treated corn silage
Number steers in lot	7	7
Av. initial weight, lb.	418.0	417.0
Av. final weight, lb.	842.0	789.0
Av. daily gain, 196 days, lb.	2.16	1.90
Av. daily ration, lb.:		
Corn and cob meal	2.2	3.0
Soybean oil meal	1.5	—
Urea	—	0.18
Corn silage	20.9	21.5
Hay	2.7	2.7
Minerals, oz.	1.0	1.4
Salt, oz.	0.7	1.0
Feed required per cwt. gain, lb.:		
Corn and cob meal	100.5	159.5
Soybean oil meal	69.0	—
Urea	—	10.0
Corn silage	966.0	1132.5
Hay	126.0	144.0
Minerals	3.0	5.0
Salt	2.0	3.5
Feed cost per cwt. gain	$13.29	$13.49

In the first experiment, 17 pounds of urea were added per ton of chopped corn as it was blown into the silo. The amount of urea added was increased to 25 pounds per ton in the second experiment. In this experiment there was no apparent loss of nitrogen from the treated silage. Thus the urea silage contained considerably more nitrogen than required by growing-fattening calves and the amount fed was limited to meet their calculated crude protein requirements. In addition to this amount of urea-treated silage, the steers were fed all of the untreated corn silage they would consume. These steers were compared to a similar lot which were full-fed regular corn silage, the same amount of ground ear corn with urea mixed with it rather than added to the silage. The results of this experiment are presented in Table 4.

In this second experiment the cattle fed corn silage and a mixture of ground ear corn and urea gained slightly faster than those fed the urea-treated corn silage and ground ear corn. The difference in gain, however, was not statistically significant. Costs of gain were somewhat higher when the urea-treated corn silage was fed, due partly to the slower gain but also because these cattle ate more silage per head daily.

The results of the first two experiments clearly indicated that the addition of urea to corn silage was a safe practice and that it did not appear to affect the palatability of the silage. In both experiments, the cattle fed the urea-treated silage ate slightly more silage per head daily than those fed the untreated silage. The numbers of cattle fed, however, were too limited to permit any definite conclusions as to the feeding value of the urea-treated silage. For this reason a third experiment was conducted with large numbers of cattle and replicated lots to study more accurately the feeding value of various supplements to corn silage for growing-fattening calves. This experiment was conducted for a 112-day period which, with the number of cattle fed, completely utilized the amounts of the various silages from the silo facilities available.

In the third experiment, three lots of seven steer calves each were fed each of five different rations. Three of these rations consisted of corn silage fed with either ground ear corn, a mixture of ground ear corn and urea or ground ear corn and soybean oil meal. The remaining two consisted of urea-treated corn silage and ground ear corn. The same amount of corn and cob meal was fed to all lots except where soybean oil meal was fed it replaced an equal weight of corn. Thus the various supplements contained approximately equal amounts of energy. One of the urea-treated silages was made by the addition of 20 pounds of urea per ton of chopped green corn and the other by the addition of 20 pounds of urea and 2 pounds of dicalcium phosphate per ton. The

TABLE 4.—Value of Urea-treated Corn Silage For Fattening Cattle

Experiment II 1953–1954

	Lot 1 Corn silage	Lot 2 Urea-treated corn silage
Number steers in lot	7	7
Av. initial weight, lb.	463.0	463.0
Av. final weight, lb.	863.0	843.0
Av. daily gain, 224 days, lb.	1.79	1.70
Av. daily ration, lb.:		
Corn and cob meal	4.1	4.1
Urea	0.20	0.20
Corn silage	21.0	22.3
Hay	2.0	1.9
Minerals, oz.	0.4	1.2
Salt, oz.	0.6	1.2
Feed required per cwt. gain, lb.:		
Corn and cob meal	228.0	239.5
Urea	11.4	11.5
Corn silage	1165.0	1311.0
Hay	106.0	111.0
Minerals	1.4	4.0
Salt	2.0	4.5
Feed cost per cwt. gain	$14.08	$15.35

dicalcium phosphate was added so that the cattle fed this silage would receive about the same amount of phosphorus as that supplied by the soybean oil meal in the rations where it was fed.

The results obtained from each lot and the averages of the three lots fed the same rations are presented in Table 5. It will be noted that, with one exception—lots 13 and 14—good checks were obtained between lots fed the same ration.

Analysis of variance of the average daily gains made by the cattle fed these various rations show that the difference between the unsupplemented lots, 1-3, and those fed urea with the ground ear corn, lots 4-6, was significant at the 5 percent level. The differences between the unsupplemented lots and those fed soybean oil meal, lots 7-9, or either of the urea-treated silages, lots 10-12 and 13-15, were significant at the one percent level. There were no significant differences between the gains made by the cattle fed soybean oil meal or either of the urea-treated silages.

TABLE 5.—Value of Urea-treated Corn Silage for Fattening Cattle

Experiment III — 1954–1955

CORN SILAGE AND CORN

Lot number	1	2	3	Average
Number steers	7	7	7	21
Av. initial weight, lb.	539.0	532.0	531.0	534.0
Av. final weight, lb.	722.0	710.0	714.0	715.0
Av. daily gain, 112 days, lb.	1.63	1.59	1.64	1.62
Av. daily ration, lb.:				
Corn and cob meal	4.0	4.0	4.0	4.0
Corn silage	19.8	19.7	19.7	19.7
Hay	2.5	2.4	2.4	2.4
Salt, oz.	0.4	0.4	0.9	0.6
Minerals, oz.	0.6	0.6	0.6	0.6
Feed required per cwt. of gain, lb.				
Corn and cob meal	245.0	252.0	244.0	247.0
Corn silage	1210.0	1239.0	1203.0	1217.0
Hay	151.0	154.0	148.0	151.0
Salt	2.0	2.0	3.0	2.0
Minerals	2.0	2.5	2.0	2.0
Feed cost per cwt. of gain	$13.92	$14.27	$13.83	$14.01

CORN SILAGE, CORN AND UREA

Lot number	4	5	6	Average
Number steers	7	7	7	21
Av. initial weight, lb.	531.0	532.0	535.0	533.0
Av. final weight, lb.	722.0	729.0	726.0	726.0
Av. daily gain, 112 days, lb.	1.71	1.76	1.71	1.73
Av. daily ration, lb.:				
Corn and cob meal	4.0	4.0	4.0	4.0
Urea	0.2	0.2	0.2	0.2
Corn silage	19.7	19.7	19.7	19.7
Hay	2.4	2.4	2.4	2.4
Salt, oz.	0.2	0.2	0.4	0.3
Minerals, oz.	0.7	0.6	0.8	0.7
Feed required per cwt. of gain, lb.				
Corn and cob meal	234.0	227.0	234.0	232.0
Urea	12.0	11.0	12.0	12.0
Corn silage	1154.0	1119.0	1156.0	1143.0
Hay	141.0	137.0	142.0	140.0
Salt	0.5	1.0	1.5	1.0
Minerals	3.0	2.0	3.0	3.0
Feed cost per cwt. of gain	$13.97	$13.49	$14.00	$13.82

TABLE 5.—Value of Urea-treated Corn Silage for Fattening Cattle—Continued

Experiment III 1954–1955

CORN SILAGE, CORN AND SOYBEAN OIL MEAL

Lot number	7	8	9	Average
Number steers	7	7	7	21
Av. initial weight, lb.	538.0	527.0	537.0	534.0
Av. final weight, lb.	743.0	744.0	745.0	744.0
Av. daily gain, 112 days, lb.	1.82	1.93	1.86	1.87
Av. daily ration, lb.:				
Corn and cob meal	2.5	2.5	2.5	2.5
Soybean oil meal	1.5	1.5	1.5	1.5
Corn silage	20.0	19.9	19.9	19.9
Hay	2.4	2.4	2.4	2.4
Salt, oz.	0.4	0.7	0.4	0.5
Minerals, oz.	0.6	0.3	0.5	0.5
Feed required per cwt. of gain, lb.				
Corn and cob meal	137.0	129.0	134.0	133.0
Soybean oil meal	82.0	78.0	81.0	80.0
Corn silage	1097.0	1032.0	1073.0	1066.0
Hay	134.0	124.0	130.0	129.0
Salt	1.0	2.0	1.5	2.0
Minerals	2.0	2.0	2.0	2.0
Feed cost per cwt. of gain	$14.35	$13.53	$14.05	$13.98

UREA-TREATED CORN SILAGE AND CORN

Lot number	10	11	12	Average
Number steers	7	7	7	21
Av. initial weight, lb.	530.0	530.0	535.0	532.0
Av. final weight, lb.	733.0	738.0	737.0	736.0
Av. daily gain, 112 days, lb.	1.81	1.86	1.80	1.82
Av. daily ration, lb.:				
Corn and cob meal	4.0	4.0	4.0	4.0
Urea	0.2	0.2	0.2	0.2
Corn silage	19.6	19.6	19.6	19.6
Hay	2.4	2.4	2.5	2.4
Salt, oz.	0.5	0.02	0.2	0.3
Minerals, oz.	0.8	0.8	0.8	0.8
Feed required per cwt. of gain, lb.				
Corn and cob meal	221.0	215.0	222.0	219.0
Urea	10.5	11.0	11.0	11.0
Corn silage	1081.5	1052.0	1086.0	1073.0
Hay	133.0	131.0	136.0	133.0
Salt	2.0	1.0	1.0	1.0
Minerals	3.0	3.0	3.0	3.0
Feed cost per cwt. of gain	$13.12	$12.82	$13.22	$13.05

TABLE 5.—Value of Urea-treated Corn Silage for Fattening Cattle—Concluded

Experiment III — 1954–1955

UREA, PHOSPHATE-TREATED CORN SILAGE AND CORN

Lot number	13	14	15	Average
Number steers	7	7	7	21
Av. initial weight, lb.	535.0	527.0	530.0	531.0
Av. final weight, lb.	753.0	723.0	732.0	736.0
Av. daily gain, 112 days, lb.	1.95	1.75	1.80	1.83
Av. daily ration, lb.:				
Corn and cob meal	4.0	4.0	4.0	4.0
Urea	0.2	0.2	0.2	0.2
Corn silage	19.5	19.6	18.9	19.3
Hay	2.4	2.4	2.4	2.4
Salt, oz.	0.3	0.3	0.3	0.3
Minerals, oz.	0.6	0.6	0.6	0.6
Feed required per cwt. of gain, lb.				
Corn and cob meal	206.0	229.0	222.0	218.0
Urea	11.0	11.0	11.0	11.0
Corn silage	1003.0	1116.0	1046.0	1053.0
Hay	125.0	139.0	133.0	132.0
Salt	1.0	1.0	1.0	1.0
Minerals	2.0	2.0	2.0	2.0
Feed cost per cwt. of gain	$12.20	$13.55	$12.92	$12.89

TABLE 6.—Feed Prices Used in Calculation of Feed Costs per Unit of Gain

Experiment	Ear corn	Soybean oilmeal	Urea	Corn silage	Hay	Salt	Minerals
	bu.	ton	ton	ton	ton	cwt.	cwt.
I, 1952-1953	$1.75	$95.00	$140.00	$12.00	$25.00	$1.50	$3.00
II, 1953-1954	1.60	80.00	140.00	11.00	30.00	1.50	3.00
III, 1954-1955	1.40	85.00	120.00	11.00	30.00	1.50	3.00

The usual close relationship between rate of gain and feed requirement per unit of gain was apparent in this experiment. Statistical analyses of the total amount of feed required per hundred weight of gain showed the same differences and of the same significance as the analyses of average daily gains.

Although the feeding of soybean oil meal or urea with ground ear corn increased the average daily gains and reduced the amount of feed required per hundred weight of gain, they did not significantly reduce the cost of gain. The reduction of feed requirement per unit of gain was nearly offset by the increased cost of the urea or soybean oil meal. The feed costs per hundred weight of gain were significantly lower, at the 5 percent level, for the cattle fed either of the urea-treated silages as compared to those fed the other three rations.

DISCUSSION

The combined results of the chemical, feeding and metabolism experiments reported herein indicate that it is feasible to add urea to chopped corn at the time of ensiling as a means of increasing the crude protein content of corn silage to be fed to fattening cattle. In considering the overall problem of using urea as a corn silage additive, there are several factors which should be considered. The results of experiments reported here provide some information concerning these questions.

Palatability of the Silage

If 20 pounds of urea is added per ton of freshly chopped corn, the concentration of urea and other non-protein nitrogen compounds arising from urea in the silage is about one percent. This means that the amount of non-protein nitrogen added is in keeping with long-standing recommendations on the levels of urea to be fed. As far as urea palatability is concerned, in 1954-1955 the silage actually contained only about 0.4 percent urea at the time it was fed to the steers or less than the one percent level.

Because of the fact that lactic acid and the short chain fatty acids combine with the ammonia released from the urea by the action of the enzyme, urease, there was no problem with the odor from ammonia in 1952-1953 or 1954-1955. However, in 1953-1954 when 25 pounds per ton of urea was added, an objectionable ammonia odor was detected, especially when the silage was held in storage boxes after removal from silo. Even this silage appeared to be palatable to the steers as they ate the urea silage as well as the control silage (see Table 4). In summary, the urea treated corn silages were found to be palatable to steer calves and to the lambs used in the metabolism studies.

Utilization of Nitrogen From Corn-urea Silage

The results of the metabolism trials using lambs indicate that the apparent digestibility of the dry matter and non-protein nitrogen in the corn-urea silage and corn compared favorably with that obtained for corn silage supplemented with corn and soybean oil meal or corn and urea. The cellulose digestibility appeared to be slightly lower for corn-urea silage. The performance of the steers fed the corn-urea silage compared satisfactorily with the performance of steers fed a conventional protein supplement.

Carotene Loss

Although only one determination was made for carotene (1954-1955) urea did not appear to be detrimental to the preservation of carotene. However, this point should perhaps be checked further. It might also be pointed out that here again temperature, silage quality, packing, etc., may be factors.

Some Practical Aspects

It may be possible under certain farm conditions that the use of urea treated corn silage might fit into a mechanized feeding operation where the advantages of using a single feed is of importance.

No experiments have been conducted at this Station on the addition of urea to meadow crop silage. Therefore no recommendations on the addition of urea to meadow crop silage can be made. Further, the addition of urea to meadow crop silage might be questioned especially if the hay crop silage was made from a crop containing a substantial amount of legumes which are high in crude protein. The work from Massachusetts indicates that the addition of urea in grass silage affected palatability adversely.

At the present time, those who may desire to mix urea with silage will probably find it difficult to obtain urea. Feed urea is now being sold only to those who have adequate equipment for thoroughly mixing the urea with other feed ingredients to avoid the danger of accidental over-feeding of urea in poorly mixed feed.

SUMMARY

Urea was added to corn silage to increase its crude protein content. In 1952-53 17 lbs. of urea was added per ton of chopped corn; in 1953-54, 25 lbs. and 20 lbs. in 1954-55.

Chemical analyses of the silage indicated that most of the added nitrogen was retained. Much of the urea nitrogen was in the form of ammonium salts of the organic acids normally present in corn silage.

Digestion studies with sheep indicated that nitrogen in this form was digested and utilized with much the same efficiency as nitrogen supplied in soybean oil meal or in a urea containing supplement.

The feeding value of the urea silage was determined using growing-fattening steers. Two experiments with a limited number of steers showed the silage to be a safe and palatable feed. A third experiment with replicated lots showed the feeding value of the urea silage to compare very favorably with that of corn silage and soybean oil meal.

It would appear that urea can be added to corn silage for fattening cattle at a level up to 20 pounds per ton of silage when stored in upright silos. No other types of silos were used in these experiments.

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